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FINAL PROJECT SUMMARY

Research on the SNC meteorites and on Mars magmatic processes in this laboratory has produced many interesting results over the past two and one-half years. These results are summarized in the following praragraphs and in the papers appended to this report.

One of the topics this group has continued to investigate during the recent grant period is the role of sulfur in Mars magmatic processes. Specifically, the solubility and speciation of sulfur has been investigated in hydrous magmas (Carroll and Rutherford, 1987; Carroll and Rutherford, 1988). These new data show that the speciation of sulfur in silicate melts is primarily sulfide ($S^{=}$) at oxygen fugacities less than those of the QFM oxygen buffer, but the sulfide is almost totally converted to sulfate at about 1.5 log units above the QFM buffer. The data also showed that sulfur solubility in silicate melts is not significantly affected by H_2O in the melt, but the solubility of sulfate is much greater than that of sulfide at similar melt compositions, P and T. Much of this experimentation was done with magmas more evolved than basalts for experimental reasons; there is important work yet to be done on basalts. Work in progress (Devine and Rutherford) on sulfur in basaltic glasses shows that the sulfide saturation curves of Houghton et al. (1974) are anomalously low because they failed to recognize the shift in S x-ray peak position with the change in S oxidation state. The abundance of $S^{=}$ vs SO_4 in basaltic glasses as determined by x-ray analysis is being calibrated as an oxygen barometer.

A second project on which we have made excellent progress is the investigation of conditions (P, T and f_{H_2O}) during SNC magma crystallization. Through careful analysis of melt inclusion phases in Chassigny and a parallel program of hydrothermal experiments, Johnson et al. (1990, ms appended) have determined the composition of melt trapped (includes 1.1 wt % H_2O) and the conditions which produced kaersutitic amphibole in these inclusions. The melt composition is similar to that determined by Longhi and Pan (1989) but is higher in MgO+FeO and lower in CaO. Synthesis and phase equilibrium experiments on these proposed SNC parent basalts are now being initiated. Johnson and Rutherford (1989) have also nearly completed a more comprehensive study of kaersutite-melt equilibria in transitional and alkali-olivine basaltic compositions which shows that (1) kaersutite is stable to much higher temperatures in alkali basalts than in tholeitic compositions and (2) crystallization of kaersutite produces quartz normative magmas from mildly alkalic basalts. An abstract describing this work is included with this report.

A third area in which this research group has been active is the experimental study of magmas in equilibrium with C-O-H (and S) fluids. Data on the abundance and speciation of C-O-H volatile species (CO_2, CO, H_2O, OH, CH_4, etc.) in silicate melts experimentally equilibrated with fluids of known composition is fundamental to understanding the role of fluids in igneous rocks. In addition to affecting the crystal-melt phase equilibria, i.e., the sequence of phases crystallizing from SNC parent basalts (Johnson et al., 1990), the abundance and solubility of these volatiles will control the physical nature of volcanic eruptions (Wilson and Head, 1983). This experimental work began with an effort to study basalt-fluid equilibria using graphite-C-O-H buffering. Equipment limitations – an inability to hold high partial pressures of hydrogen in the internally heated pressure vessel – prevented long duration high P and T experiments. The internally heated pressure vessel has since been completely remade and is now being used with hydrogen-rich gases. While this pressure-vessel re-construction was in progress, we investigated CO and CO_2 solubilities in rhyolitic melts. Fogel and Rutherford (1990a, ms appended) found that the CO_2 solubility in rhyolite follows a Henries' law behavior up to CO_2 pressure of 2 kb, but at higher pressures the solubility increase with increasing pressure is significantly less than predicted by extension of the Henries' law behavior. FTIR analyses also show that only molecular CO_2 is present in the high silica melt. In contrast, the data we have collected from experiments on andesitic and basaltic compositions show a gradual increase in carbonates and a decrease in molecular CO_2 as the melt SiO_2 increases. Interestingly, the total carbonate + molecular CO_2 in basalts is very similar to, but slightly less than the total CO_2 disolved in rhyolite under the same conditions. Fogel and Rutherford have also determined the CO and CO_2 solubilities in silicate melts under graphite-saturated conditions (Fogel and Rutherford, 1990b). The replacement of CO_2 by CO in the fluid phase increases the total CO_2 in the melt, but the CO is not quenchable – it reacts to form CO_2. In a related project, Fogel and Rutherford (ms) have refined the available P-V-T data for H_2 and CO and incorporated it into a fugacity model for C-O-H species at igneous pressures and temperatues. In order to understand the role of volatiles in planetary basalts, we also have studied C-O-H-S fluids in terrestrial basalts. The abstract of a paper (Metrich et al., MS) submitted for publication is included.

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